

8.0 RF Coverage Acceptance Testing

8.1. *Overview of RF Coverage Acceptance Testing*

The State requires that RF Coverage Acceptance begin at the Region Level and proceed in parallel with the remaining compulsory equipment, functional site and subsystem and operational feature testing. The State understands that the project is large and a complex relationship of manufacturing, staging, testing, deployment schedules exist which must be managed to the site construction schedules and backhaul availability.

The State requires that RF coverage acceptance testing will be performed on a Regional basis.

8.2. *Audio Quality Performance*

The State agrees with certain portions of TIA **TSB 88-C** coverage testing methodology. That methodology does not accommodate particular concerns of the State and therefore the State will generally follow TIA TSB 88-C with modifications to address these concerns defined in this RF Coverage Acceptance Test.

The system design shall be based upon Delivered Audio Quality (“DAQ”) of “3.4” using qualitative voice testing for the proposed technology defined by TIA **TSB 88-C**.

The State requires that all tiles will be tested for Delivered Audio Quality and deemed pass or fail based upon an DAQ score of “3.4”. Prior to each DAQ test, vendors shall provide a complete tile list. Delivered Audio Quality (DAQ) testing will not commence until all identified tiles are served by its complement of deployed and operational radio sites. Tiles are defined later in this RF coverage acceptance test.

8.3. *Automated Measurement Tests*

Automated Measurement Tests (“AMT”) shall provide a method to measure and record RF signal strength, data error rates and other RF channel performance parameters. Automated Measurement Tests are for informational purposes only for the voice system and do not constitute acceptance of any voice performance criteria.

AMT shall use calibrated reference receivers and calibrated data error rate detection recording equipment. AMT data and results will be continuous measurements of signal strength, data error rates and other performance parameters **along a defined “drive route. The drive route shall circumnavigate both the interior and exterior of the Region in order to assure both Source and Target radios traverse single site coverage, multi-site coverage from sites within the Region, multi-site coverage from sites associated with other Regions (as appropriate) and coverage from sites external to the Region under test.** All

measurements shall be geo-referenced with GPS data and time stamps in order to provide a repeatable drive route and measurement process.

Prior to each Regional AMT test, vendors shall provide a complete ~~drive route map and associated~~ tile list. AMT testing will not commence until ~~all drive routes and tiles are identified and approved by the State and~~ the Contractor advises the State that it is prepared to perform the AMT test for the data system. AMT testing will be performed concurrently with voice quality testing (DAQ).

The State requires AMT to be performed to obtain a baseline measurement and repeatable measurement process for system maintenance of signal strength and data error rates ~~along specific drive routes~~. AMT is not a substitute for voice quality testing and is performed for informational purposes only.

8.4. *Tiles and tests per tile*

The State requires uniform tile pattern for RF coverage testing throughout the Region and State geographic area. DAQ and AMT testing procedures will utilize this common set of uniform tiles.

Tiles shall be 1 square mile (approximately 2.6 square kilometers). Tiles shall be geo-referenced to a State plane coordinate system. Tiles shall be defined to include a geographic area of the State and an area ten miles into the Atlantic Ocean from the State coastline. Tiles shall also be defined to encompass the Chesapeake Bay and all navigable waterways within the borders of the State.

RF coverage acceptance test plans, documentation and electronic files shall uniquely enumerate tiles beginning at the far western edge of the coverage area and proceeding east to the far eastern edge of the coverage area. The identification of tiles shall be based upon a plan agreed to by the contractor and State. ~~Tiles running from west to east shall be labeled alphabetically beginning with A and proceeding sequentially. Tiles beginning at the extreme southern edge of the coverage area and proceeding north to the extreme northern edge of the coverage area shall be labeled numerically beginning with 1 and proceeding sequentially. Therefore, the extreme south-western tile will be labeled A-1.~~

Region testing shall incorporate all tiles ~~in Maryland~~ at the State's ~~within a 3-mile~~ border ~~of the State in the case of land based tiles~~ and 10- miles from ~~beyond the~~ State's coastal barrier islands, or in the event there are no barrier islands, from the coast ~~or State border~~ in the case of the Atlantic Ocean tiles.

The state also requires the depiction of a 40 dBu contour of sites into any adjacent state and the District of Columbia to provide evidence of compliance with the Orders¹ of the Commission as well as Region 20 Plan.

¹ *Id.*

DAQ testing requires a single Push-to-Talk (PTT) two-way voice test per tile. A single DAQ test within a tile passes only if both:

- 1) Two-way message occurs, and
- 2) Both teams score the DAQ Test equal to or greater 3.4.

A single DAQ test within a tile fails if there is either:

- 1) One part of the two-way message is not received, or
- 2) If either part message is scored less than the DAQ score of 3.4.

A Region requires 95% of all tiles, including bordering tiles **in Maryland and** assigned to adjacent Regions **and other States**, to pass the Delivered Audio Quality Testing.

The State notes that some tiles will incorporate land in Maryland and another state or the District of Columbia. If any part of a tile is in Maryland, that portion in Maryland shall be tested unless the State determines that the tile is inaccessible.

8.4.1 Physical in-building testing

In addition to other provisions of this Appendix, in-building testing procedures shall follow TSB 88-C Section 5.6.3.1 that reads “Conduct a moving test by walking in a circle, approximately 1 meter in diameter, while conducting a subjective test or capturing sufficient data for an objective test, §5.6.4.4. Alternatively a non-moving (static) test could be conducted. Agreement on the type of test needs to be obtained prior to system design. A random selection of buildings is recommended. One building of the appropriate class, nearest the center of a CATP grid is recommended”. Addendum #16

8.5. RF Coverage – **Simulated Portable In-Building Voice Quality Test [Field Test]**

This Acceptance Test Procedure (ATP) is used by the State for verification of portable in-building coverage in the State of Maryland defined service area based upon **simulating building loss and** evaluating the voice quality of digital calls made **in randomly selected buildings** throughout the test area boundaries. **The test may be used to verify coverage in specific or mandatory buildings.**

The coverage design will be evaluated on the success in providing the required in-building coverage throughout the State’s service area. The basic network coverage design shall be applicable to vehicles, aircraft, railroad trains, and water vessels traveling at speeds up to 150 mph. It is the desire of the State of Maryland to have coverage provided within **these** buildings from the 700 MHz infrastructure, with limited in-building enhancements for **certain** critical buildings.

Measurement and verification methodologies are provided to ensure an understanding and compliance of coverage acceptance testing. At least 95% of all test locations within the state shall meet or exceed the required coverage threshold for both voice and data. It should be noted that contractor-provided coverage maps will be used only for analysis of alternatives and will have no bearing on the acceptance of the system provided.

The Contractor shall supply a GPS receiver to provide accurate position information for each grid; industrial grade measurement receivers to provide RSSI data for a single or multiple sites; a computer with an internal clock that coordinates and records the grid location; and a roof mounted antenna. The grid pattern is overlaid onto street maps **and a test route determined**. The test route should pass through each grid at least once but not more than twice, as far as is practically possible.

Buildings are categorized as either non-critical or critical. These are characterized as either 12 dB or 24 dB buildings depending on if they are inside or outside the defined urban 24 dB coverage area. The Contractor shall guarantee the coverage inside buildings within the Channel Performance Criterion [CPC] identified below.

Design Criteria

Service Area	The geographic boundaries of the State of Maryland, except for the Atlantic Ocean coast of the State where the requirement is 10 miles from the coastal barrier island, or in the event there are no barrier islands, from the coast. This geographic area includes all urban, suburban, rural, and open areas, including <u>all</u> navigable waterways.
CPC	DAQ 3.4
Validated Service Area Reliability	95% (where the service area is defined in Appendix 2)
Building losses	24 dB within the specified urban area boundaries, and 12 dB outside this area
Two types of buildings:	Non-critical buildings, Critical buildings and Special Coverage Areas

This ATP is in conformance with the principles set forth in the Telecommunications Industry Association (TIA) Telecommunications Systems Bulletin TSB88-C, titled “Wireless Communications Systems - Performance in Noise and Interference-Limited Situations - Recommended Methods for Technology-Independent Modeling, Simulation, and Verification”. TSB88-C has defined Channel Performance Criterion (CPC) as the specified minimum design performance level in a faded channel. TSB88-C also provides a set of Delivered Audio Quality (DAQ) CPCs that define subjective voice quality performance applicable to both analog voice and digital voice systems. These DAQ definitions are provided in Table 1.

Table 1. Delivered Audio Quality Scale Definitions

Delivered Audio Quality	Subjective Performance Description
DAQ 5.0	Speech easily understood.
DAQ 4.5	Speech easily understood. Infrequent Noise/Distortion.
DAQ 4.0	Speech easily understood. Occasional Noise/Distortion.
DAQ 3.4	Speech understandable with repetition only rarely required. Some Noise/Distortion.
DAQ 3.0	Speech understandable with slight effort. Occasional repetition required due to Noise/Distortion.
DAQ 2.0	Understandable with considerable effort. Frequent repetition due to Noise/Distortion.
DAQ 1.0	Unusable, speech present but unreadable.

TSB88-C defines a service area as a boundary of the geographic area of concern for a user, and states that validated service area reliability shall be determined by the percentage of test locations in the service area that meet or exceed the specified CPC. The State proposes a Bounded Area coverage design for the State of Maryland as defined in TSB88-C wherein coverage predictions are made out to the boundary of the defined service area and coverage is verified throughout the service area out to the boundary edges. To accomplish coverage verification, the State’s service area will be divided into multiple one-mile by one-mile grid patterns to obtain a uniform distribution of grids throughout the jurisdictional service area, ~~to provide a test confidence level of 99% or greater.~~ The grid pattern is to be overlaid onto maps provided by the Contractor.

RF coverage using this ATP is verified by evaluating the voice quality of digital test calls from a portable radio ~~in randomly selected buildings~~ throughout the State’s defined jurisdictional boundary service area. Simulated in-building voice quality tests will be performed ~~in any grid where there are no buildings to test.~~ At each ~~random building or simulated building or outdoor location,~~ a test call is placed from the portable user to the dispatcher (an inbound call), as well as from the dispatcher to the portable user (an outbound call). The inbound and outbound test calls at each location are graded using the DAQ definitions in Table 1. Scores that equal or exceed the State’s specified CPC of DAQ3.4 are considered acceptable (PASS), and those lower than DAQ3.4 are not acceptable (FAIL).

~~If a random building fails a voice quality test then additional tests may be made to determine if the loss characteristics of the failed test locations within the building exceed the State’s specified 12 or 24 dB random building loss levels.~~

8.6. *Test Equipment and Preparation*

Portable radios from each manufacturer as proposed will be used for the voice quality test. The portable radios will be worn on the belt and equipped with a shoulder-mounted

speaker/microphone (SM) without shoulder-mount antenna. The State will supply a vehicle for driving to the test locations and the Contractor will provide the vehicle location equipment and associated software.

Each portable radio shall be equipped with an attenuator to simulate in-building conditions. The Contractor shall also provide unity gain quarter-wave antennae with magnetic mounts for placement on a vehicle roof and connection of the antennae to the portable radios used in testing. It is the responsibility of the Contractor to obtain a sufficient number of attenuators and antennae to support the number of test teams required for the coverage testing.

Prior to the beginning of the testing process for each Region, the Contractor may identify and inspect all portable radios used for testing. Each tier of portable radio shall be tested through this process. The Contractor shall certify that each portable radio to be used in the test has been evaluated and found to be operating within the manufacturer's specifications.

Evaluated portable radios shall be presented to the State for use in coverage testing. Through the use of an electronic testing device, approved by the State, the Contractor shall demonstrate to the State that the radio transceiver is operating within specifications. In the presence of the State's representatives, the Contractor shall insert the attenuator on the radio and through the use of the same electronic device, visually depict that the signal has been attenuated by 22.9 or 34.9 dB (12 or 24 dB as required plus 10.9 dB to represent body loss). Once the State witnesses this demonstration of attenuation and agrees that the radio meets the requirements of attenuation, the portable radios and their associated attenuators used for coverage testing shall remain in the sole physical custody of the State for the duration of the process.

At least once each week during the testing process, all portable radios shall be re-examined by the State to ensure that the attenuator is performing within specification. Either the Contractor or the State can require additional tests to ensure that the attenuated radio is operating with the required 22.9 or 34.9 dB of signal loss. If an attenuator becomes defective during the test, all tiles examined with the defective attenuator shall be re-tested. The period of re-testing shall extend back to the date of the last equipment check in which the attenuators and associated portable radios were found to be within specification.

During such weekly or other re-tests, the portable radios shall remain under the immediate supervision of State representatives while the Contractor's representative performs the actual testing.

At the conclusion of the testing process, the radio attenuators shall be returned to the Contractor.

A State representative will drive the State-supplied vehicle for the field team and the Contractor representative will assist with navigation to the test points. The test data will

be recorded immediately after the grid test is completed and collected mutually at the end of each test day. In order to comfortably accommodate the field team and all required testing equipment, the State will provide full sized vehicles with sufficient leg-room in both the front passenger seat and rear passenger seats. At the beginning of each test day, the individual field teams will be assigned a block of grids to be tested for the day. Each test team will be expected to conduct coverage test for eight (8) hours a day for several weeks in each phase of testing excluding weekends, and holidays. It is anticipated that there will be a lunch break in addition to the eight (8) hours required per day.

A GPS receiver package will be utilized in the test team's transport vehicle, to assist the test team in determining that the building under test is within the proper grid. A laptop computer will be loaded with a geographical database that will display the State's test grids with the service area. In conjunction with this GPS receiver, the laptop computer will track the transport vehicle's location on the map display. ~~In this way, the test team will know which grid they are in, and can easily determine if the building they are preparing to test is in the proper grid.~~

Prior to performing the tests, each site that provides coverage to the test grid must be audited to verify that the radio system is operating properly. The audits will verify the antenna configuration, the power into the antenna, the antenna installation, and the frequency of the test transmitter. The Contractor shall provide all test equipment necessary to perform the site audits.

8.7. *Test Planning*

8.7.1. State Grid Size and Test Location

TSB88-C recommends that coverage verification be made at a statistically significant number of random test locations, uniformly distributed throughout the service area. To accomplish this, the service area is divided by a grid pattern as an aid to test planning.

The State ~~recommends~~ ~~requires~~ a 1-mile by 1-mile grid pattern to obtain an even or uniform distribution of test grids throughout the State's service area. The grid pattern is overlaid onto street maps ~~and a building is randomly selected within each grid, and, to the extent possible, selected building locations in adjacent grids should not be clustered close to one another (e.g. minimum separation of 0.2 x 0.75 mile grid pattern definition).~~ Simulated in-building voice quality tests will be performed ~~in any grid where there are no buildings accessible to test.~~

~~A State test grid is defined as one having its center point in the State service area. Any grid that is along the border of the State of Maryland service area will be tested according to the following definitions:~~

- ~~1) If that grid is more than 75% water, then the grid will be tested as a simulated in-building grid.~~

- 2) If that grid is less than 75% water, then the portion of land which is inside State of Maryland service area will be tested using the building test.

Any grid that is inaccessible, or not tested at the State's discretion, will have coverage waived and will not be scored or counted statistically. If the field test team is denied access to test a randomly selected building location within a grid, then other buildings locations will be randomly selected making every effort to locate an accessible building for testing. If the team is unable to test any buildings within a grid then a simulated building test shall be performed for that grid. The State may at its sole discretion decide not to test any random buildings within a grid or any simulated building grid. Any grid not tested at the State's discretion will have coverage scored as a PASS. Along the border of the service area, any grid with more than 1/3 of its area within the service area will be tested. Such tests will be performed in the portion of the grid that is within the service area. The final selection of test grids will be mutually agreed to by State of Maryland and the Contractor prior to the coverage test. The Contractor will prepare the final grid file for the coverage acceptance test.

8.7.2. Use of Different Tier Radios in Testing In Building Grid Size and Test Location

A statistically significant number of random test locations uniformly distributed throughout each selected building will be tested. For each grid and at each agreed upon test location within a building, the portable user to dispatcher [inbound], and the dispatcher to portable user [outbound] test calls are performed using the metrics in Table 1. If the message is not understood on the first attempt, then the test point is marked as "FAIL". The audio quality test is then repeated for each manufacturer radio within the building as specified elsewhere.

The testing process requires that each tier radio be used for the conduct of the test. The State's testers shall randomly select a radio from each tier for testing so that during the day of testing, each tier of radio shall be used in the testing process. It is not necessary to test each tile with each tier of radio. There will be one test per tile and as stated above, the State's testers will randomly select the tier of radio to be used for the testing of the individual tile. The evaluation team shall endeavor, but not be required, to achieve an equivalent distribution of radios by tier for the testing process each day.

8.7.3. Non-Critical Buildings

Non-critical buildings are all those buildings not identified as a "Critical Building" and within the service area. For the purposes of coverage testing, a building will be randomly selected by the State in each grid. Large buildings are defined as up to 24 dB signal penetration if inside the defined 24 dB urban area boundary, or up to 12 dB outside of this area. Each building to be tested will be as close as practical to the grid center within

~~each grid, and to the extent possible, selected building locations in adjacent grids should not be clustered close to one another.~~

~~Test the ground floor—four corners and center. Results need to pass all five locations. Below grade, elevators, shielded rooms, etc., will not be tested.~~

~~If the building fails, it will be notated. There can only be 5% of building failures in the State [need to pass 95% of test grids of each building]. Therefore, an occasional fail is acceptable up to 5% of the overall in-building tests. For example, if there are 500 buildings tested, up to 25 buildings in the State can fail.~~

~~If the overall 95% in-building coverage commitment is not met, then the failed buildings may have to be measured for penetration losses, as outlined below.~~

If it is determined that more than 5% of the tiles in the Regional service area have failed, then corrective action shall be taken by the Contractor. This action shall be at no cost to the State, either for the corrections or for re-tests to verify adequacy of the corrections. It shall be understood that a failed test point is a symptom of a weak coverage area. No correction will be acceptable that is designed to specifically correct only the failed test point; distributed antenna systems in a failed building are specifically prohibited as a method to correct this coverage deficiency. Allowed corrective actions include (but are not limited to) reorienting antennas and adding new sites. The failed test grid and each grid bordering on the failed test grid shall be retested. If such modifications have potential to impact coverage elsewhere, then those areas shall also be included in the re-test. The State plans to be fair and reasonable as to what areas (if any) will be re-tested.

~~Unless otherwise specified, test grids will include stairwells but will exclude elevators, areas with metal or screened walls, floors and areas below grade level such as basements, parking garages, utility tunnels, and boiler rooms, and any other location in the building where radio coverage is not planned, or expected, or permitted. The Contractor and the State will mutually identify all areas of each random building that will be excluded from testing. Test grids that are within excluded areas of a building will not be tested and will not be counted in the reliability calculations.~~

8.7.4. Critical Buildings and Special Coverage Areas

As discussed, it is the intent of the State of Maryland to provide primary coverage inside critical buildings using the 700 MHz communications system infrastructure; in-building enhancements within critical buildings will be addressed by the State under separate contract.

The list of Critical Buildings can be found in Appendix 8, *Critical Facilities*. The list of Special Coverage Areas are defined in Appendix 9, *Special Coverage Locations*. All critical buildings and Special Coverage Areas will require testing to identify the level of coverage provided by the contractor's coverage design.

Large Critical Buildings: Critical buildings that exceed the maximum building loss (12 dB or 24 dB) for their grid are considered to be outside the wide area 95% overall test. Such buildings are termed “Large Critical Buildings”. Large Critical Buildings will be tested in detail to provide the State with an understanding of the locations and extent of dead spots on each floor, both above and below grade. The Contractor shall provide a test report to the State for each such building that includes a floor plan depicting dead spots. This data will be used by the State to identify in-building signal enhancements. The State reserves the right to either award such interior enhancement to the Contractor, or to release a separate competitive procurement for such work.

The test plan is based on evaluating coverage at a minimum of 20 random locations per floor inside each critical building with each test point no less than five feet nor greater than 75-feet from the previous test point. Initial tests will be conducted on the first three [3] floors of the building, and continuing upward until three [3] consecutive floors pass. In addition to, or on each of the floors, testing will be performed in elevators, stairwells, and basements. Basement locations will include electrical, mechanical and boiler room locations.

Small Critical Buildings: Critical Buildings that are within the building loss (12 dB or 24 dB) for their grid are considered “Small Critical Buildings”. In such case, that building will be used to verify coverage in that grid. Unlike randomly selected buildings, Small Critical Building tests will include a minimum of 20 random locations inside each critical building with each test point no greater than 75 feet from the previous test point.

The State of Maryland may, at its discretion, decide to test only a single location near the middle of each floor and forego testing all remaining planned test locations within a random building if it determines that the building is adequately covered. Likewise, the State may, at its discretion, decide to test only a subset of locations within a building and forego testing all remaining planned test locations within that random building if it determines that the building is adequately covered. The State also reserves the right to waive testing of any building in any grid that it likewise determines that coverage is adequate. Testing of any grids within a building or any random building waived by the State of Maryland will have coverage scored as a PASS.

8.8. Grading of Building Test Locations

The voice quality test requires two Contractor representatives and two State representatives. One Contractor and one two State representatives will be the Field team, who will travel to the randomly selected building in each grid, walk to the agreed test grids in the building, perform the inbound calls, and grade the outbound calls. A second Contractor and two State representatives will be the Base team and will remain at the dispatch location, grade the inbound calls, and perform the outbound calls.

To reduce the time required for the coverage test, more than one Field team may operate at a time, and a single Base team may support more than one Field team.

The voice test call at each location within a building consists of a short message representative of typical public safety call duration's and includes the identification of the building and location being tested. The suggested inbound test message is “TESTING BUILDING YYY, GRID NUMBER XXX followed by a phonetically balanced sentence”. To ensure that the message is understood, the dispatcher then repeats the inbound test message. The dispatcher will then make a similar outbound test call. The suggested outbound test message is “CONFIRMING BUILDING YYY, GRID XXX followed by a phonetically balanced sentence”. The field team will then verify receipt of the dispatcher’s test message. As they perform the tests, the teams will rotate through the list of phonetically balanced sentences found in Appendix C of the document, “IEEE Recommended Practice for Speech Quality Measurements”².

Each of the representatives grades each test call using the Table 1 DAQ definitions and records the test score for each test location. PASS or FAIL determination is made separately for the inbound and outbound calls at each location. For each call direction, a test location is deemed to PASS if it meets or exceeds the State’s requirement for DAQ 3.4 voice quality for each manufacturer’s subscriber radio from both graders. If both the majority of graders agree that the voice quality does not meet the defined DAQ 3.4 criteria, then that test location fails for the direction being graded. If a score differs between testers at a location that results in a failing score from only one tester, that location will need to be tested again to determine the cause of the discrepancy. If the discrepancy cannot be rectified, then that grid will be marked as “FAIL”.

~~8.9. Digital Voice Quality Analysis This Section has been Deleted~~

~~An individual test grid location within a building is determined to PASS the digital voice quality test if both the inbound and outbound digital calls at that location have been scored as a PASS.~~

- ~~1) Any grids within the building waived testing by the State as previously discussed will be scored as a PASS.~~
- ~~2) A random building is deemed to meet the digital voice coverage requirement if the percentage of test grid locations that receive a PASS score equals or exceeds the State’s specified 95% acceptance criteria.~~

~~If a random building does not meet either the digital voice quality coverage acceptance requirements, then additional tests may be made, at no cost to the State, to determine if the loss characteristics of the failed test grid locations within the building exceed the 12 or 24 dB building loss category specified by the State.~~

² IEEE Transactions on Audio and Electroacoustics Vol. AU-17, No. 3, September, 1969

- 1) If the measured building loss at a failed test grid is less than or equal to the State's specified building loss category, then the test grid will remain recorded as a FAIL.
- 2) If the measured building loss for the failed test grid is greater than the State's specified building loss category, then that test will be discarded and another building will be tested in the affected grid.
- 3) The PASS/FAIL determination for the building is then recomputed discarding all test results that have a measured building loss greater than the specified building loss.
- 4) In order to expedite the process, the State's will defer building loss measurements of failed test grids/buildings until all randomly selected buildings have been tested.

8.10. *Building Loss Measurement Procedure-This Section has been Deleted*

If a building fails the voice quality test, the Contractor may elect to measure and compare the signal strength inside the building to an on-street signal strength measurement. Measurements will be taken both immediately around the building as well as inside the building in a small area centered on the face and corner of each side of the building (i.e., the A face, the AB corner, the D face, etc.). The building loss will be defined as the difference between the mean of the outside measurements and the mean of the inside measurements. There are several possible outcomes based upon the results of this measurement.

- 1) If the building loss is less than the maximum limit for that location (either 12 dB or 24 dB), then the grid is marked as "FAIL".
- 2) If the building loss exceeds the maximum limit for that location (either 12 dB or 24 dB), then a different building within that grid will be tested.

8.11. *Simulated Building Test Grid Testing and Analysis*

Simulated in-building voice quality tests will be performed through the use of portable radios with antenna systems attenuated to simulate a 12 or 24 dB signal loss in those grids where there are no buildings accessible for test. Portable in-vehicle test calls will be performed at a selected test location near the center of each such grid, to the extent possible, with the portable radio user inside the test vehicle and the test radio located inside the vehicle shall be immediately adjacent to the door. Portable radios worn on the left hip with a D-clip attachment will be used to simulate in-building operations. The portable radio user will not remove the radio from the belt loop or raise it above seat level. The portable radio user will conduct the simulated in-building test only speaking into the speaker microphone clipped to the user's shoulder boards or collar. The test vehicle may be in motion during the test; however, the speed of the vehicle shall not exceed 5 miles per hour.

At each test location the portable user to dispatcher (inbound) and the dispatcher to portable user (outbound) test calls are performed. If the message is not understood on the

first attempt, the location is marked as a “FAIL”. Message content will be similar to that used for the random building tests.

Each of the test team representatives grades each test call using the Table 1 DAQ definitions and records the test score for each test location. PASS or FAIL determination is made separately for the inbound and outbound calls at each location. For each call direction, a test location is deemed to PASS if it meets or exceeds the State’s requirement for DAQ 3.4 voice quality from both graders.

Separate digital voice tests are required for each manufacturer’s device at each simulated building grid.

A simulated building test grid is determined to PASS the voice quality test if both the inbound and outbound digital calls at that location have been scored as a PASS.

8.12. Test Acceptance

The test acceptance is performed on a regional basis. The sum of all portable voice quality tests receiving a pass divided by all tests shall be 95% or higher for each region (total tests passed divided by total tests conducted). The PASS/FAIL scoring for each tile random building, mandatory building, and simulated building tested in the State of Maryland is then summed. Included will be any grids and buildings where the State waived testing and that were scored as PASS as discussed earlier.

The portable in-building digital voice quality test is deemed to meet the coverage requirements if the percentage of all test grids that receive a PASS score equals or exceeds the State’s minimum 95% acceptance criteria.

The installed radio system in the Region State of Maryland is deemed to meet the portable in-building voice quality coverage requirement if the digital voice quality tests meet the 95% acceptance criteria.

8.13. Results Presentation

A test report is provided by the Contractor that includes:

- 1) The total number of test grids in the tested Region in the State of Maryland differentiating the number of random building grids, the number of simulated building grids, and the number of Water grids;
- 2) The name/address and or GPS coordinates of the location random building tested within each grid;
- 3) The radio tier used in the test number and location of individual test locations within each building;

- 4) A copy of the inbound or outbound grading templates used by each grader for each grid building, including grids locations that had testing waived;
- 5) Certification from the Contractor that the Contractor's representatives had no access to test portable radios. A copy of the inbound or outbound grading templates used by each grader for each simulated building and mandatory building;
- 6) The PASS/FAIL score results for each tile with the individual results electronically depicted on a map. random building, simulated building, and mandatory buildings;
- 7) Building loss measurement data if required for a building;
- 8) The overall percentage PASS calculation for the voice quality tests; and
- 9) A statement of overall coverage test acceptance or failure for the State of Maryland.

8.14. Automated Measurement Test (AMT) Procedure *Data Application Testing*

This Acceptance Test Procedure (ATP) is used for wireless data RF coverage analysis and functionality based on automated data collection and verification. The State requires AMT to be performed to obtain a baseline measurement and repeatable measurement process for system maintenance of received signal strength indicator (RSSI) and bit error ratio (BER) along specific drive routes.

This procedure provides an accurate, statistically valid, repeatable, objective, and cost-effective method to verify wireless data coverage and functionality requirements are met.

The coverage design will be evaluated on the success in providing the required coverage throughout the various regions of the State's service area. The basic network coverage design shall be applicable to vehicles, aircraft, railroad trains, and water vessels traveling at speeds up to 150 mph. It is the desire of the State of Maryland to have coverage provided from the 700 MHz infrastructure, with limited in-building enhancements for certain critical buildings.

Realizing there are physical barriers which may produce "dead spots", the system shall provide portable coverage 95% of the time while being operated on the hip, simulating the inside of a structure, providing a net error free data throughput of 7.2 kbps minimum per 6.25 kHz equivalent channel bandwidth. Coverage measured by using a mobile antenna, of unity gain, at a height of 1 meter above ground level — roughly equivalent to a passenger car fender or trunk lid.

8.14.1. Unused

Supported Data Types

Supported applications that transmit and receive various forms of data content, including but not limited to:

- 1) Short Messaging (e.g. up to 254 bytes),
- 2) Text and American Standard Code for Information Interchange (ASCII) data,
- 3) Image and Graphics (e.g. JPEG files),
- 4) Binary files (e.g. MP-3 files), and
- 5) Video (e.g. from streaming to full motion).

All above data message shall be automated via continuous looping for the vehicles traversing the drive route.

The State requires GPS based automated units to collect RF signal performance parameters throughout the service area. Parameters will include RSSI bit/block error rate.

8.14.2. Unused

Data Transfer

The data types listed in subsection 8.14.1 shall be supported for the following transfer modes in both conventional and trunked operation:

- 1) Radio to radio
 - i. Radio to many radios
 - ii. Radio to dispatcher
 - iii. Dispatcher to radio
 - iv. Dispatcher to many radios.
- 2) Data Spectral Efficiency
 - i. Net data throughput efficiency shall be defined as the actual number of bits per second per Hertz of channel width transferred, excluding overhead/control, forward error correction, and retransmission.
 - ii. Net data throughput efficiency shall be at least 0.576 bits per second per Hertz of channel width.

8.14.3. Setup

The Contractor provides all mobile test equipment for the signal strength and bit error ratio measurements. The test equipment consists of four modular units: a GPS receiver to provide accurate position information for each measured data point; industrial grade measurement receivers to provide RSSI and BER data for a single or multiple sites; a computer with an internal clock that coordinates and records the test data; and a roof mounted antenna. The test equipment may contain multiple receivers to facilitate gathering data simultaneously from several multi-site or simulcast sites at common measurement locations. The signal from the antenna shall be attenuated as described in section 8.6.

8.14.4. Drive Route Planning

Section 5.7 of TSB 88.3-C recommends that measurements be made at a statistically significant number of random test locations, uniformly distributed throughout the service area. The service area is divided by a grid pattern as an aid to the development of a drive test route with an approximately equal distance traveled in each grid. Thus, a large number of test samples is collected and evenly distributed throughout the defined service area.

The State requires recommends a 1-mile by 1-mile grid pattern to obtain an even or uniform distribution of grids throughout the State of Maryland jurisdictional boundary service area. The grid pattern is overlaid onto street maps and a drive test route determined. The drive route should pass through each grid at least once but not more than twice, as far as is practically possible.

Signal strength, bit or block error ratio rate and other measurements and two-way messaging functionality will be made in all accessible grids within the State's defined service area boundary. Test measurements along the drive route that are outside of the defined service area boundary will not be counted. Any grid that is inaccessible, or not tested at the State's discretion, will have coverage waived and will not be scored or counted statistically.

Any accessible grids within the service area boundary that the State decides not to test will have coverage scored as a PASS in the reliability calculations.

8.14.5. Data Measurements

All data is collected with the AMT equipment mounted inside the test vehicle (standard passenger vehicle) with an external antenna mounted on the outside and centrally located on the vehicle's roof, with no other equipment installed on the roof.

Each radio system One base station at each site under test transmits a n unmodulated carrier on one selected channel, and measurements of this signal are made at equal distance intervals throughout the entire drive route. With the test vehicle in motion along the drive route, a local median mean signal measurement (RSSI) is made every .1 mile (typically) by finding the median of averaging a minimum of 50 200 sub-samples data points within a 28 to 100 θ wavelength measurement window. By sampling the radio environment in this way, the estimated mean value is within ± 1 dB of the actual value with 95% confidence. Vehicle velocity must not exceed 150 miles per hour to ensure adequate number of points over the measurement window.

Simultaneous with the RSSI measurement, a bit error ratio measurement is performed on a minimum of approximately 5,000 bits.

8.14.6. Drive Test Data Analysis

The data records collected from the drive test are post-processed using all RSSI and BER mean measurements within a region of the radio system the State of Maryland jurisdictional boundary service area.

Post processing will compare to Vendor RF predictions and develop baseline measurements for system performance monitoring (Section 8.3).

~~The minimum acceptable signal level at a data terminal is adjusted to the mobile measurement reference point using defined loss factors (e.g. excess signal required to penetrate each random building category, body loss, etc.). 95% of service area must provide bit error rate less than or equal the design requirements including adjustments for building and body loss factors. A comparison is made between the mean measurement points in the service area and this adjusted minimum level, denoted the adjusted signal threshold.~~

~~Points that equal or exceed the adjusted signal threshold value are recorded as PASS and those below are recorded as FAIL.~~

~~The installed radio system coverage is deemed to meet the coverage requirements if the ratio of the number of PASS points to the total number of points in the service area equals or exceeds the validated service area reliability percentage acceptance criteria that is shown.~~

8.14.7. Results Presentation

The data records are plotted on a map showing the test grids, the areas tested and the test results. Different pen colors are used to show ranges of measured mean signal levels RSSI and BER. The ranges to be presented will be mutually agreed upon between the State and the Vendor. A test report is also provided that summarizes the test results.

8.14.8. Offeror Requirements

Offeror shall describe two-way Bit/Block error rate and Received Signal Strength bit error ratio and received signal level testing.

The Offeror shall define handoff threshold parameters and settings for subscriber units to automatically evaluate, select and become active as it travels between radio sites.

The Offeror shall define any and all infrastructure (base station, site or regional Master site) and radio subscriber device parameters that are modifiable to change the radio subscriber site-to-site roaming and handoff behavior. For parameters modified on

infrastructure equipment, the Offeror shall define how the radio subscriber is updated, and how the radio subscriber maintains the update for the particular site.

The Offeror shall define how one site can be independently modified in roaming/hand-off threshold parameters compared to other sites and how that configuration is maintained for the infrastructure and subscriber radio units.

Offeror shall define the ability to have the roaming and handoff parameters adjusted for the outbound link (base to subscriber) and the inbound link (subscriber to base) and the ability to measure and set these parameters independently.

Offeror shall affirm that the RF link budget and all roaming/hand off threshold parameters are accounted in the RF prediction maps and calculations to meet the stated coverage requirements.

8.15. Completion of RF Coverage Testing

RF Coverage Acceptance requires the following:

- 1) Successful completion of all RF Coverage testing requirements,
- 2) Resolution of all RF Coverage Testing punch list items, and
- 3) Delivery of all RF Coverage Testing, AMT and DAQ procedures and test results documentation.

Once RF Coverage Testing and documentation are successfully completed, then all equipment, site, and subsystems of the Region can transition to the 30-day Operation Test.

9.0 Thirty-day Operation Test

9.1. *Thirty-day Operation Test Overview*

Once State-wide coverage testing has been successfully completed, all regional equipment configurations and RF sites shall undergo a 30-day Operation Test. The test requires a contiguous 30-day period where there are no failures or performance degradation affecting 25% of the capacity or capability of a radio site, a Master Site and switching equipment, a Region or the State.

9.2. *Thirty-day Operation Test*

State-wide and all Regional configuration and 3rd party equipment: The State requires all Regions to be deployed and configured including 3rd party manufactured equipment. The Thirty-day Operation test must demonstrate all features and functions of State-wide system and have no failures as defined in the Thirty-day Operation Test requirements in this section.

RF Channels (base stations and capacity) – A failure of 25%, or greater, of the RF base stations deployed at a radio site, or 5% of the radio site's talkgroup capacity will constitute a radio site failure.

Radio sites – Failure of 5% of the radio sites within any one Region will not be accepted. Failure of 5% of the radio sites within one Region will constitute a Region failure. Failure of 5% of radio sites within more than one Region will not be accepted. Failure of 5% of the radio sites between two or more regions constitutes one or more Region failures. Failure of 15% of radio sites across the State will not be accepted. Failure of 15% of the radios sites when distributed between Regions, multiple Regions and Statewide configurations constitutes either a Multi-region or a State-wide failure.

Master Site and Region Switch – any failure of any Master site or any regional switching equipment will not be accepted regardless of the number of Regions comprising the State-wide design and regardless of any capacity, performance and functionality retained during the failure for a radio site, a Region, Multi-Regions and State. Any Master site and regional switch located at the Field Staging Facility must also pass the Thirty day operational test and is not considered part of the capacity of any Region, Multi-Region or State configuration.

Operational Performance Testing –

1. ~~Demonstrate and~~ Verify that the system is capable of, but not limited to, supporting at least 100,000 unique addresses, 5,000 talk groups, OTAP, OTAR,

- voice data contention and the grade of service at the system upper operational boundaries.
2. Demonstrate ~~and verify~~ the total access delay time plus latency time between two subscriber radios in any two or more cells of the system ~~is less than 700 milliseconds~~ from push to talk (PTT) to reception and passage of voice information.
 3. Demonstrate that all equipment performs as specified through a 30-day, minimum, field test of all system functions and features by field operators and dispatchers and by repeating of specific tests as deemed appropriate.

9.3. *Completion of 30-day Operation Testing*

Thirty-day Operation Acceptance requires the successful completion of the Thirty-day acceptance testing requirements, results, and documentation.

Once all Thirty-day Operation Tests and documentation are successfully completed, then all equipment, site, and subsystems of the Region can transition to Level 6 Multi-Region Testing.

Revised 12/3/2009